Recognition of the image of a person, based on Viola-Jones

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Abstract. In the field of image analysis, technological evolution is considered as an innovation through the application of algorithms in cameras for the detection and identification of objects and people, although these recognition tasks are complex for a computer. The general context of the application of the algorithms in the recognition of images is not known, therefore, the following research question is posed: What algorithm based on Viola-Jones allows the recognition of the image of a person? The objective of this investigation is to determine an algorithm based on Viola-Jones that allows to detect and identify the image of a person. This research was made through an algorithm comparison methodology, which allowed improving the recognition of a person's image pattern, based on the techniques and methods found in pattern recognition. The results obtained will serve as support for future studies, considering that the application of the Viola-Jones-based algorithm allowed the recognition and identification of a person's face in five different frontal perspectives, through a digital camera and was a fundamental basis to determine substantial improvements in the recognition of the image of a person.

Keywords: Algorithm detection, Viola-Jones algorithm, person identification, image recognition.

1 Introduction

According to [1] pattern recognition systems are developed as part of a framework that allows continuous monitoring of human behavior in the area of assisted living, rehabilitation and entertainment, injury detection, sports, elderly care, energy efficiency lighting and surveillance in smart homes.

Within the contexts of technological evolution, there is the application of algorithms in cameras for the detection of objects, which is of great importance in development and innovation. There are several factors that motivate this research, being the optimization in the consumption of electric energy and the application for the safety of people among the most important.

In [2] object recognition is defined as the process of identifying a specific object, the class of objects in an image or video. Therefore, according to [3] this type of detection

not only focuses on finding the kind of object to be detected, but also locating the extent of the object in an image.

From the study in the detection of objects, the innovation in the facial and people detection begins. According to [4] several researchers have developed methods and techniques to detect people in images, considering that the study of an effective method for the recognition of image patterns is continued.

The objective of this investigation is to determine an algorithm based on Viola-Jones that allows the re-knowledge of the image of a person, using a camera as video input. The methodology used is based on the analysis, comparison and verification of the algorithms found, allowing to identify the pattern of a person's image.

According to [5], the authors consider that facial recognition systems play a vital role in many applications, such as surveillance, biometrics and safety, for which the authors in [6] establish that the Viola-Jones algorithm is currently one of the most used to solve search problems of a person's face.

Recognition tasks according to [7] are considered complex for a computer because they have problems in the processes of object classification, border detection, movement tracking, etc. For this reason, there are different proposals for the recognition of objects, facial expressions, faces and human patterns. Thus, the authors argue in [8], [9], [10], that facial recognition methods based on local characteristics use information from the face (eyes, nose, mouth) to globally identify a person.

This research is based on the Viola-Jones algorithm and according to [11], the authors consider it as an integrated method for facial detection, monitoring and estimation of head postures. This article describes the research on the development and implementation of the algorithm that allows the identification of the face of a person and as a proposal for the result of this investigation, the algorithm that allows the recognition of the image of a person is detailed.

This document is organized as follows, in Section 2 the related works on our research are described. Section 3 focuses on the description of the methodology used in relation to the analysis of the algorithms found, considering the proposed question. Section 4 describes the results obtained and the development of the algorithm for the recognition of a person's face. Section 5 details the proposal that describes the algorithm for the recognition of a person's image. Finally, the conclusions of this investigation are presented.

2 Related works

2.1 Background

The recognition works for images of human being have been proposed by several authors. Considering [6], they state that the Viola-Jones algorithm was created to look for the image of a person's face in a visible range as a radiation pattern and motivated by Viola, who considers in [12], that the selection of characteristics is achieved through a modification of the Ada-boost procedure and basic Haar functions. According to [13] the authors proposed a static vector image where the value of the vector at each point

is a function of the motion properties in the spatial location, corresponding to a sequence of images represented in two templates with values for the recognition of the human being.

For the authors of [14] the recognition of different types of human activities such as running, limping, jumping, among others, has long been a subject of study in biomechanics, kinesiology, psychophysics and physical medicine. Due to the importance of this topic, from the research for the recognition of the different activities mentioned, other research topics arise, such as the recognition of colored object images and facials of a person.

There are various systems to perform facial recognition, according to [15] the most common is to include an enrollment phaser, during which images of the users' face are taken and used to create a template that is stored in a database (gallery images). Thus, the technology used in the recognition of patterns in people is related to the facial emotions of movement of the human pupil, according to [16] it is of great importance considering that the movement of the human eye is a rich source of information on behavior and human intention. There are studies that are based on the recognition of the face and objects of different shapes and colors, considering [17] the authors explain that the facial recognition of a person arises due to a wide range of real-life applications; for this reason, several face recognition algorithms have been developed through the years, in addition, algorithms were used in different branches of science that were adapted under the same concept to find the most effective. The authors of [18] consider that there are several ways to distinguish a person from another person: the face, the fingerprint, the gait and the iris are among the biometric properties, which are widely used for the recognition of people.

It is important to know that for now facial recognition is the main focus due to the inexpensive implementation and the non-intrusive nature of image acquisition, which is possible without the active participation of a subject. Therefore, there is no algorithm and model that is considered effective for the recognition of patterns in the detection of people. The following are the models, the techniques that served as the basis for this research for the development and application of the algorithm.

2.2 Models

In the review of related works, three models were found that allow the recognition of patterns, which are considered in this investigation.

a) Hidden Markov (HMM): It is a statistical model to describe the characteristics of a stochastic process, according to [19] it is considered important in computational methods for the classification of human physical activity and the application in pattern recognition.
b) Convolutional Neural Network (dCNN): It is a model that is used to classify images, group them by similarity and perform recognition of objects within scenes. The authors of [20] argue that this method allows a set of data to be formed and tagged with

attributes. It is based on algorithms that can identify faces, people, traffic signs, tumors and aspects of visual data. This Convolutional Neural Network (dCNN) model can be implemented with Matlab and is available at Neural Network Toolbox™.

c) Support Vector Machines (SVM): It is an algorithm model associated with learning that analyzes the data used for classification and backward analysis, as [21] assigns data from one or another category, making it a non-probabilistic binary linear classifier, this being a system of nonlinear human recognition, which effectively updates the classification parameters when a new framework is presented and classified. This method was first used in a pioneering document about the history of artificial vision [22]. Thus, Navneet Dalal and Bill Triggs introduced the characteristics of the Oriented Gradient Histogram (HOG) in 2005.

Of all the models, the SVM was chosen to be fully implemented in Matlab, because in real time it detects people not included in an upright position. In addition, this model is related to classification and regression problems; this will be used in our research through the algorithms described.

The SVM model is used to perform recognition of people in a real application [21], and with the criteria of the authors of [6], the implementation of the Viola-Jones algorithm allowed us to obtain in an integral way the representation of the original image frame of a person minimizing the amount and time of necessary calculations.

2.3 Techniques

Table 1 shows the techniques found and used by the recognition models described in item 2.2. According to [11] , the Viola-Jones technique in some cases does not detect faces.

Table 1. Techniques found in recognition models

Techniques	HMM	dCNN	SVM	Ref.
Recognizes face images	x		x	[20], [23]
Recognizes images of objects		x	x	[20]
Effective monitoring and control in recognition	x		x	[24], [21]
Captures the image at an angle of 0 ° to 90 °	x		x	[20], [23]
Captures the image at an angle of 90 ° to 180 °			x	[23]
Captures the image at an angle of 180 ° to 270 °			x	[21]
Captures the image at an angle of 270 ° to 360 °	x		x	[20], [21]
Captures the image in a span of 1 to 5 minutes	x	x	x	[25], [26], [24]
Captures the image at a distance of 5 meters			x	[25]
Detection of false objects and false faces	x	x	x	[26], [25], [27]
It does not capture the image having a lot of light on the place	x	x	x	[27], [26], [25]

2.4 Algorithms found

Based on the research work carried out, Table 2 shows the algorithms that allow the recognition of an image with their advantages and disadvantages.

Table 2. Recognition Algorithms.

Algorithm	Description	Advantages	Disadvantages	Ref.
MCMC (Markov chain Monte Carlo)	Algorithm based on Hidden Markov's model. Applied to the HMM model, it is used for the recognition of human activities.	Set of latent movements that are selectively shared between multiple trajectories and between different activities, they are learned efficiently by the MCMC algorithm.	It has several limitations, for example the assumption of independence.	[24]
WSMTAL (Weakly Supervised Multi-Type Attribute Learning)	Algorithm based on the Convolutional Neural Network (dCNN) model. It considers contextual signals and progressively increases accuracy using a limited number of people tagged data.	Divides human attributes into multiple types, where each one contains several incompatible attributes and only one of them can be positive.	Convolutional Neural Network (dCNN) does not need more training on target data sets. It is not so accurate.	[20]
Viola-Jones	This algorithm is based on a series of weak classifiers called Haar-like-feactures that can be calculated efficiently from an integral image.	This algorithm stands out for its low computational cost since it allows to be used in real time.	Occlusion is a problem for this algorithm since it could not detect efficiently.	[28], [6], [29]
Eigen-Faces	The EigenFaces algorithm is a facial recognition method based on the analysis component approaches.	Evaluates images of size 23x28 pixels in an order to compare interpolarization.	It is not yet coupled with (SVM) Support vector machine and (ANN) Artificial Neural Network.	[30], [31]
Ada-boost	Adaboost is a boosting algorithm presented by Freund and Sachapire in the generation of online learning.	Used to select features, and train classifiers. This procedure dramatically increases the speed of the detector.	Takes weak classifiers, calls them multiple times each time with different distribution over X.	[28], [32]

2.5 Viola-Jones

The purpose of this investigation is to determine an algorithm based on Viola-Jones that allows to detect and identify the image of a person and their respective mathematical equation (1). Whereas this work is motivated in the detection of faces.

According to [28] the detection of faces on real-time video on which the calculation of the integral image is based.

$$I(x,y) = \sum_{xi<x,yi<y} i(x',y') \quad (1)$$

Where:

(x, y) is the integral image calculated in pixels, (x', y') is the original image. Using the integral image, any sum of a rectangular area ABCD can be calculated efficiently, (2):

$$\sum_{(x,y)\in ABCD} i(x',y') = \mathrm{I(D)} + \mathrm{I(A)} - \mathrm{I(B)} - \mathrm{I(C)} \quad (2)$$

3 Methodology

3.1 Search criteria

For the development of the proposed objective, the following question is asked: What algorithm based on Viola-Jones allows the recognition of the image of a person? which is considered as a criterion for the search of algorithms that allow to identify the pattern of recognition of the image of a person. The research was carried out through the search for information in several scientific repositories, using criteria such as:

a) Recognition of the pattern of the image of an object.
b) Algorithm for the recognition of the image of a person's face.
c) Recognition of the pattern of the image of an object AND Algorithm for the recognition of the image of a person's face.
d) Algorithm for the recognition of the image of a person's face patterns AND of the pattern of the image of an object.

Table 3. Results obtained from scientific repositories

Source	Elegible Studies	Relevant studies	Main Studies	%
ACM Digital Library	5936	20	11	22,92%
IEEE Xplore	305	34	6	12,50%
Science Direct	1042	92	18	37,50%
Springer	2840	38	13	27,08%
TOTAL	10123	184	48	100,00%

In Table 3, 10123 articles related to the criteria are shown as a result of the search, of which 48 main articles based on pattern recognition research were considered. These were classified into models and techniques.

3.2 Framework of work

The purpose of our research is to determine an algorithm that allows us to recognize the image of a person, so a framework was developed, in which the processes are described through the flowchart shown in Figure 1.

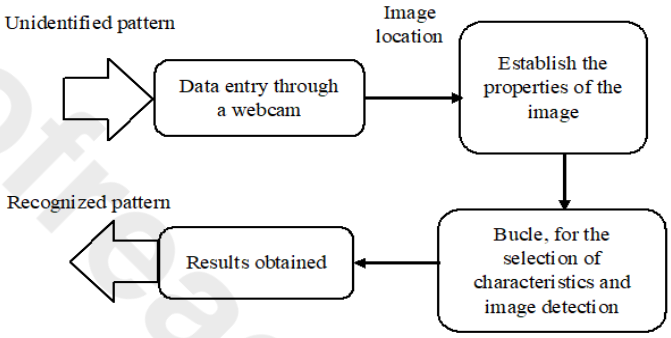

Fig. 1. Flowchart for image recognition

The hardware used to complement the improvement of the algorithms was a computer with 1.70 GHz CPU, Intel ® Core™ i3-4005U processor, RAM 4.00 GB, Windows 10 64-bit operating system, TOSHIBA Web-HD camera and as software used Matlab 2017b.

4 Results

Considering the objective of our investigation and the question, what algorithm based on Viola-Jones allows the recognition of the image of a person ?, Algorithm 1 was found, described as a reference in this study and that through different tests and checks allowed us to obtain the algorithms listed in this document as a result.

4.1 Representation of Algorithm 1

As a result of our investigation, algorithm 1 was found, which was considered as a reference in this study for the respective verifications, development and application of the other algorithms.

Algorithm 1: Reference

```
Data: image, detector people, imqdetec, imshow, frame, bboxes, f
image=vision.detectorpeople ( );
obj=imaq.VideoDevice ( );
set (obj);
   while (true)
      frame=step(obj);
      bboxes=step (faceDetector,frame);
      Imqdetect=insertObjectAnnotation(frame, ,bboxes,);
      imshow(Imqdetec)
      exit of imshow
      f=findobj();
   end
end
```

4.2 Development of Algorithm 2

As a result of the research and respective tests, using Support Vector Machines to create real-time classifiers and pattern recognition in Matlab, Algorithm 2 was developed.

The improvement of algorithm 2, applied in facial detection, was developed in five scenarios, using Matlab 2017b.

1) Scenario 1. A person's face is detected through the webcam in real time.
2) Scenario 2. The algorithm and through a webcam detects the face of a person 50 cm away. See Figure 2.
3) Scenario 3. The algorithm was improved so that the real-time video lasts until the user decides to stop or end the detection.
4) Scenario 4. The algorithm detects the face of a person in a video in real time at a distance of 90 cm. See Figure 3.
5) Scenario 5. The algorithm detects the face of a person in 5 different frontal positions with an angle of 15 ° Left-Right, within a real-time video, see Figure 4.

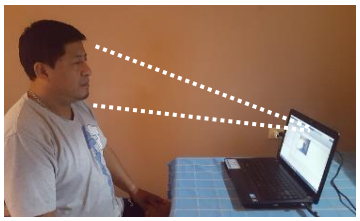

Fig. 2. Detection a 0,90 m

Fig. 3. Detection a 0,50 m

At the end of scenario 5, the facial recognition of a person in 5 different frontal perspectives with an angle of 15 ° in identification and left lateral detection and

similarly 15 ° in identification and right lateral detection was obtained; See Figure 4, which shows the capture of the face in a rectangle (frame).

Fig. 4. Facial recognition of a person

Next, algorithm 2 is represented, which allowed us to recognize a person's face, basing its design on Viola-Jones.

Algorithm 2: Facial recognition of a person

```
Data: video, faceDetector, obj, frame, bboxes, IFaces
faceDetector=vision.CascadeObjectDetector;
obj=imaq.VideoDevice;
  set (obj);
  figure ();
  while (true)
      frame=step(obj);
      bboxes=step (faceDetector,frame);
      IFaces=insertObjectAnnotation(frame, ,bboxes,);
      imshow(IFaces)
      f=findobj();
      if (isempty(f))
         close (gcf)
         break
      end
      pause (0.05)
   end
```

5 Proposal

Considering the analysis of algorithm 1 and development of algorithm 2, it was possible to determine the proposed algorithm, which answers the question: What algorithm based on Viola-Jones allows the recognition of the image of a person?

The algorithm has been developed with an innovative factor for the detection of the image of a person in real time through a webcam, which is done through an infinite loop that captures each frame that the camera receives and through a command in Matlab, the person is detected. See Figure 5.

For validation, the instructions are used to determine if an image exists using the face gradient histogram (HOG), classified in the support vector machine (SVM).

3,34 m–3,50 m 3,34 m–4,50 m 3,34 m–5,50 m 3,34 m–6,50 m 3,34 m–7,00 m

Fig. 5. Recognition of imagen of a person

The proposed algorithm was developed based on tests performed in two cases, considering the height of the person, see Table 4 and Table 5 respectively. The data obtained in the recognition of the image of a person are related based on the parameters: height of the person, distance range, camera height, detection angle, recognition of the person.

In Table 4, the data obtained allow us to determine how true the recognition of the image of a person is in a distance range of 3.34 m to 7.00 m considering the height of the person as 1.65 m and an angle of detection of 28°. The recognition of the image of the person in a range of 0 to 3.34 m was also determined as False.

Table 4. Data obtained, first case stature 1,65m

Camera height (m)	Range distance (m)	Person stature (m)	Detection angle	Person Recognition
0,88	0.0. – 3.34	1,65	28°	FALSE
0,88	3.34 – 3.50	1,65	26°	TRUE
0,88	3.34 – 4.00	1,65	24°	TRUE
0,88	3.4 – 4.50	1,65	22°	TRUE
0,88	3.34 – 5.00	1,65	20°	TRUE
0,88	3,34 – 5.50	1,65	18°	TRUE
0,88	3.34 – 6.00	1,65	16°	TRUE
0,88	3.34 – 6.50	1,65	14°	TRUE
0,88	3.34 – 7.00	1,65	12°	TRUE

Table 5 shows the data obtained and described as True in relation to the recognition of the image of a person in a distance range of 4.28 m to 7.00 m considering the height of the person as 1.78 m and an angle of 16° for the detection. The recognition of the image of the person in a range of 0 to 4.28 m will also be considered False.

Table 5. Data obtained, second case stature 1,78m

Camera height (m)	Range distance (m)	Person stature (m)	Detection angle	Person recognition
0,88	0.00 – 4.28	1,78	16°	FALSE
0,88	4.28 – 4.50	1,78	14°	TRUE
0,88	4.28 – 5.00	1,78	12°	TRUE
0,88	4.28 – 5.50	1,78	10°	TRUE
0,88	4.28 – 6.00	1,78	8°	TRUE
0,88	4.28 – 6.50	1,78	6°	TRUE
0,88	4.28 – 7.00	1,78	4°	TRUE

5.1 Representation of the proposed Algorithm

Next, the proposed algorithm for the recognition of the image of a person is described.

Algorithm 3: Recognition of imagen of a person

```
Datos: video, peopleDetector, obj, frame, bboxes
peopleDetector = vision.PeopleDetector( )
obj=imaq.VideoDevice ( )
   set (obj);
   figure ( );
   while (true)
        frame=step(obj);
        bboxes=step (peopleDetector,frame);
        obj_p=insertObjectAnnotation (frame,bboxes);
        imshow(obj_p,)
        f=findobj( );
        pause (0.05)
   end
   release (obj)
end
```

6 Conclusion

After the respective investigations, tests and analysis of the algorithms studied, through their implementation and verification using the Image Acquisition Tool and Computer Vision System Toolbox tools of Matlab R2017b, its effectiveness and efficiency in pattern recognition could be verified. The functionality of the algorithm found and considered as a reference to distinguish and differentiate in recognition patterns was also verified. Finally, with the implementation of the second algorithm, it allowed us to detect

and recognize the image of a person's face in 5 different frontal perspectives with an angle of 15 ° at a distance between 0.50 m to 0.90 m.

These analyzes were fundamental for the development and implementation of the proposed algorithm that allows answering the question and describing as true the recognition of the image a person based on Viola-Jones in a range of 3.34 m to 7 m and 4.28 m to 7 m, considering the angle of detection and the height of the person. Recognition in the range of 0 to 3.34 m and 0 to 4.28 m is considered false.

In table 4 and table 5, data obtained as a result of the application of the proposed algorithm and the parameters considered for the validation in the detection of the image of a person are described, in which every 0.50 m increment was established as distances its analysis, which allowed to substantiate that the greater the distance, the smaller the angle in the detection, thus it was determined 7 m to be the final distance in the two cases considered for the analysis of the algorithm.

The results obtained in both cases, taking into account the height of a person, allow validating the algorithm to recognize a person in an established range and contribute to future research in performing a faster, simpler and less complex detection.

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